Art. II.—*On the Active Principle of Malaria.* By Daniel P. Gardner, M. D., Professor of Chemistry, &c. in Hampden Sidney College, Va. &c.

The subject will be discussed in the form of propositions, for the better classification of details. The profession are therefore made the judges in the matter, and their acceptance or rejection of the arguments brought forward, will substantiate or destroy the theory advocated in the following pages. The propositions, under which the facts adduced to show the nature of the active principle of malaria are classified, are:

1st. Sulphuretted hydrogen gas exists in the stagnant waters, and atmosphere of certain marshes.

2d. The character of malarious regions is similar to that of those in which sulphuretted hydrogen is generated.

3d. Certain agents have been supposed to give activity to the exhalations arising from marshes, called malaria.

4th. The properties of malaria are fully recognised by the profession.

5th. Sulphuretted hydrogen is the active agent in the production of those forms of malarious fever met on the sea coast, and the diseases belonging to the same class found inland.

Proposition I. *Sulphuretted hydrogen gas exists in the stagnant waters, and atmosphere of certain marshes.*

1. Numerous conjectures have been made concerning the cause of malaria. Nearly every agent, from carbonic acid to certain theoretical germs, have been brought forward as the deleterious matter. Amongst these, sulphuretted hydrogen has occupied a prominent position. But all attempts to demonstrate its existence had failed, until Professor Daniel, in 1841, succeeded in detecting large quantities of the gas in some specimens of water, submitted to his notice by the British admiralty for analysis. These specimens were from the African rivers Bonny, Sierra Leone, Mooney, Congo, and the adjacent seas. Mr. Garden, of London, also found the same gas in water from the Bonny and Lagos. Dr. Marcet, in the Yellow seas. All these localities are reputed for their insalubrity, and it was natural to attribute to the gas some share in producing it.

2. But it is not only on the pestiferous shores of Africa that malaria exists. Practitioners in the United States have designated numerous localities which are remarkable for the peculiar diseases attributed to malaria. It becomes therefore an interesting question to ascertain whether sulphuretted hydrogen exists in all these places. The labour of one individual is not competent to the task, but it may become the lot of one to direct the attention of the pro-

fession, and put into their hands the means of deciding this much vexed and important question.

3. The difficulty, which has been found insuperable, in testing for this gas, is the extremely small quantity in which it exists in the air. A sufficient bulk of atmospheric air could not be submitted to examination to detect its presence. But instead of securing specimens from marshes, it appears extraordinary, that until very lately, the air or at least the stagnant water had not been examined on the spot. With a view of effecting this examination, I considered how an apparatus might be constructed to allow large volumes of gas to pass constantly across some reagent calculated to detect sulphur. The fruit of my labours was unsatisfactory, and I was reduced to the necessity of bringing the reagent simply in contact with the air, and water, without being able to increase the quantities of the former coming directly across it. The substance best calculated to answer all the necessary indications is silver, which when properly prepared is an exceedingly delicate test for sulphur, and not liable to be attacked by the many agents which act upon lead, copper, &c.

4. The silver must present a pure surface. To effect this, it should be kept in contact with a boiling solution of caustic potash and alum. The process must be continued through one or two changes of the solution, if the metal be very unclean. The last should be evaporated to dryness, for by this means the potash is made to act upon any copper that may be present as an adulteration. When the process has been successful, the silver presents a granulated surface of a dull lustre, and immaculate purity. The coins in circulation are beautifully cleaned by this method, and become as good reagents as any other pieces of silver. They were used in the experiments instituted by myself.

5. The delicacy of pure silver as a test for sulphuretted hydrogen is exceedingly great. A solution was made containing one drop of hydrosulphate of ammonia in 120,000 grs. of water. A five cent piece placed in it was discoloured in the course of a few minutes, and became of a decided light yellowish brown colour in two hours, without agitation. This is by no means the minimum which it will detect. The amount of sulphur present in the solution was determined by precipitating the whole of that substance out of a known quantity of the hydrosulphate by means of the nitrate of lead, collecting the precipitate, washing, drying and weighing it; allowing the ingredients of the sulphuret of lead to be in the ratio of their equivalents, or as 104 to 16.1, the quantity of sulphur present in a drop was found to be $\frac{1}{25}$th of a grain. So that metallic silver, perfectly pure, is able to detect sulphur in a solution containing one part in three millions of water. As a means of determining the amount of sulphuretted hydrogen in mineral waters it is without comparison the best test, for all the addition to the weight of the silver is pure sulphur, and the metal is not acted upon by carbonic acid,

which is nearly always present, and difficult to separate from the sulphuretted hydrogen.

6. Having learnt the delicacy of silver, it appeared to me, that by long exposure to the action of the water, and air of marshes, it might become stained by sulphuretted hydrogen, if that gas existed in such places. Accordingly, a number of prepared coins were disposed in suitable positions for its detection. Three small rivers, Buffalo, Briery, and Appomattox were selected, and coins suspended in them by a stout silk thread, passed through a perforation made in them before cleaning; the stagnant water lying upon the surface of marshes, and produced by sluggish springs, was also tested in the same way, not allowing the metal to touch the soil, but suspending it from the branches of shrubs. The currents which set out from cold springs, and which are known in the country as spring branches, were also examined in the same way, at different points from their origin. In the air, over rivers, and marshes, coins were exposed. The description of money used was various, five cents, ten cents, twelve and a half cents, and twenty-five cent pieces were all taken, according to the change in my possession. They were first perforated in a marked place, so as to be recognised, next cleaned and dried, then carefully weighed, furnished with a string, and lastly carried to the place selected. Great care was taken to keep the surface unsullied by the touch of the finger or otherwise. The number of pieces used was thirty, and all the suspected places within a circle whose diameter is seven miles were examined.

7. In twenty-two hours after the first set of these coins were deposited, two were found distinctly stained, one in a marsh, and the other in a spring branch flowing through a marshy piece of land, and receiving constant additions of stagnant water from it. Two other coins immersed for the same time in the Buffalo river exhibited no sign of change. This great difference is worthy of remark, and points out the locality wherein the gas is generated. It was found to be a law, from repeated examination, that the shallow waters of marshes contained the most, and rivers the least amount of gas; the coins placed in the latter sometimes required a month, and those suspended in air even more time for discoloration. In all the experiments I made, the silver was ultimately stained.

8. The discovery of sulphuretted hydrogen in the air, is a new and important feature of these researches. In one coin placed over the Buffalo river it required five weeks to produce the sulphuret stain, but a quarter of a dollar suspended eighteen inches from the soil, in a marsh over stagnant spring water, was discoloured in a week. In every case where the gas was detected rapidly in water it was found in the air over it, in a greater or less time. This must necessarily be the case, for a solution of sulphuretted hydrogen exposed to the atmosphere must continually give off that gas, by exosmose, until the air and water contain equal quantities. Hence the gas abounds where it is generated, both in the air and water, and diminishes in

quantity as the distance increases from the place of its production. That sulphuretted hydrogen exists in air must be admitted, when the discoloration of white lead paint in cities is considered; the houses painted with it in London, and Paris, become of a light dingy yellnw in a few years. Plate, and other silver wares lose their polish and become tarnished in houses. These changes are undoubtedly due to sulphur existing in the atmosphere of such places.

9. That the discoloration observed in the coins was due to the formation of a sulphuret was proved directly by the reduction of the silver. Two pieces were selected, and weighed, after an exposure of ten days. They had both acquired $\frac{2}{100}$ths of a grain access of weight, but as their diameters were not similar, the increase was not in the ratio of their surfaces, but as 26 to 35. This was due to the difference of the places from which they had been taken, the one from a marsh, the other from a spring branch. The process adopted for the detection of sulphur on the coin, was by passing a stream of hydrogen gas, over the metal inclosed in a green glass tube, and made red hot; the effluent gas discoloured nitrate of silver in the manner of sulphuretted hydrogen.

10. Having proved that sulphur exists in these localities, my next object was to examine the causes of it. In the foregoing experiments, the immediate source was a marsh, containing much decaying vegetable matter, a rich alluvial soil saturated with *spring* water, or that which had percolated through the soil, and heated by the temperature of midsummer. These four conditions are all worthy of examination.

11. Alluvial deposits contain much vegetable matter, their blackness is due to it in some measure. This vegetable matter is in a constant state of decay, the rapidity of which is proportional to the access of oxygen, and the warmth of the season. Such accumulations are therefore interesting, as laboratories in which powerful affinities are bringing about numerous striking changes. They form the scene of many important events worthy of close attention. Let a sulphate be brought within the reach of these powerfully deoxidizing masses, and it will be decomposed by the destruction of its acid.

12. The second element, of the sites in which sulphuretted hydrogen was detected by me, is decaying vegetation. The effect of this, differs in no wise from the action of the organic constituents of alluvion. In its decay, carbon is left in excess, and exerts all its powerful affinities to assume the gaseous form. But vegetables contain certain inorganic constituents, which are of considerable interest in the changes under contemplation. Of these, the sulphates of lime, soda, potassa, and magnesia have been detected. In the decay of a plant containing any of these salts, the results will depend upon the presence or absence of water. If dry, they will be unchanged; but if water and heat be present, the sulphuric acid will be decomposed. The leaf contains a large proportion of the salts existing in a plant.

13. But of all the agents discovered in these localities, spring water is the most important. It is usually impure. It contains the soluble salts of the land through which it has percolated. These must from the nature of the case differ. Muriates, sulphates, phosphates and carbonates have been found by different analysts. Spring water is seldom free from sulphate of lime, or magnesia—the former imparts to it the quality denominated hardness. When these ingredients are present in any quantity, and the water is kept in contact with decaying vegetable matter, they are decomposed, oxygen is abstracted and sulphurets are produced—the latter in their turn, yield sulphuretted hydrogen with the first nascent hydrogen they encounter. The final compound of these bases, is most probably a carbonate. That sulphuretted hydrogen is thus produced, is a matter of demonstration. Prof. Daniel put decaying leaves together with water containing sulphate of soda in a jar, and subjected them to the action of a summer's heat; in three months, sulphuretted hydrogen was abundantly given off, and the salts decomposed. If no sulphate be present, either in the vegetable matter or water, the gas will not be given off. Hence, to apply the result of this decisive experiment to our purpose, no locality, the soil of which is destitute of the sulphates, can generate the deleterious gas.

Thus we have reached a generalisation which is indisputable, and of the greatest practical importance. For it affords the means of discriminating, even in the most unpromising situations, between a healthy and insalubrious site.

To ascertain the presence of sulphates, the addition of a few drops of a solution of chloride of barium is all that is necessary. If the cloudy precipitate that falls is unsatisfactory, boil the spring water until it is evaporated to a small compass, and test again. If a sulphate be present, the white, dense sulphate of baryta will fall, a salt that cannot be mistaken from its utter insolubility. This test is so simple, that any member of the profession can decide upon the existence of sulphates, and therefore of sulphuretted hydrogen, in any place whatsoever. The test for the gas detailed in sections 4, 5, 6, is not less simple, and therefore, there are placed in his hands both the theoretical and experimental means of deciding on this grave question, at all times.

It is also a fact, no less valuable than the preceding, that the practitioner is enabled to decide, by analysis, the comparative amount of the deleterious gas in different situations. It is not extent of surface, depth of soil, geological structure, or the amount of evapoiating water that concerns him, but the quantity of the sulphates. This point I have had the means of examining, during several years, in consequence of the analysis of many specimens of sulphur, and other mineral waters, from the counties of Prince Edward, Cumberland, Buckingham, Lunenburg, and Halifax in this state. Those waters, containing the greatest amount of the sulphates, yielded larger quantities of sulphuretted hydrogen than those which contained but

little of these salts. All the specimens of sulphur water, examined by me, were from alluvial deposits. Two saline waters contained sulphate of magnesia and lime, but they were procured from rocky places, in which no vegetable matter existed. Three specimens were from alluvial situations, but contained no sulphates, and therefore no sulphuretted hydrogen gas. But few mineral waters, are as rich in sulphates as the ocean. Schweitzer found in 1000 grs. of water from the British Channel, 3.7 grs. of sulphate of lime, and magnesia. Laurens 7.17 grs. in the same bulk from the Mediterranean. Murray, in a wine pint, 21.6 grs. of sulphate of magnesia. Prof. Daniel, from 80 to 120 grs. of sulphuric acid in a gallon of the waters from the African coast. The sea stations are the most dangerous, when vegetable matters are present, as on alluvial coasts; but the open expanse of old ocean is without the least trace of malaria. Rivers, before they become salt by contact with the ocean, contain less saline matters than marshes, in consequence of the showers of rain water which reach them without percolating the soil and dissolving out the sulphates incorporated in it.

14. The temperature must be warm, for the production of these changes in the sulphates. The amount of heat necessary to commence the decomposition is unknown, and can be determined only by experiment. It is known to be above the freezing point, for water is necessary. An elevated temperature is highly favourable, and the more elevated, so long as water remains, the more favourable it is for the production of the gas. This is an immediate consequence of chemical laws, and is further borne out by the quantities of sulphuretted hydrogen discovered in the tropical waters of Africa and China. In the same proportion, the fatality of malarious diseases increases. Temperature is, therefore, an element in our researches, not to be overlooked.

15. It is not to be understood, that because sulphates are found in certain waters, the gas must exist in them also—for it is not the presence of one condition, but of all, that produces the results under consideration. So sulphuretted hydrogen may be found in waters which contain no sulphates—this appears to be the case in the mineral waters of Aix la Chapelle analysed by Bergman; Moffat by Garnet, and Harrowgate in England. Such exceptions point out to our attention, the existence of other sources of the gas. It is believed that at Harrowgate, the destruction of large quantities of pyrites yields it; the iron combining with oxygen gives up its sulphur to nascent hydrogen. Other minerals, and districts may yield the gas, without disparagement to the fact adduced. As far as my examinations in Virginia go, I believe that sulphuretted hydrogen is produced in springs by the process under examination. Dr. Amédée Fontan suggests the same process as yielding the gas in the waters of Germany, Belgium, Switzerland and Savoy.

16. Thus, having proved that sulphuretted hydrogen exists in the air, and water of marshes—having showed the usual sources of this substance, and the process by which it is eliminated—it remains to show that the localities

which are remarkable for the production of malaria agree with those fitted to generate the gas. The circumstances under which sulphuretted hydrogen is most abundantly produced are—sufficient water not to dilute the gas, exposure of the soil to the air, high temperature, and abundant supplies of vegetable matter and soluble sulphates. Hence sea-marshes, the deltas of tropical rivers containing salt water, &c. exposed to certain states of drought, are the most prolific sources of *sulphuretted hydrogen* and *malaria*. Nor is the bilge water of ships, in contact with decaying wood, or other vegetable matter, to be overlooked.

Proposition II.—*The character of malarious regions is similar to that of those in which sulphuretted hydrogen is generated.*

17. In a narrative of an expedition into the interior of Africa, along the river Niger, by Messrs. Laird and Oldfield, the following remarks occur. "The principal predisposing causes of the awful mortality, were in my opinion the sudden change from the open sea to a narrow and winding river, the want of the sea-breeze, and the prevalence of the deadly miasma, to which we are nightly exposed from the surrounding swamps. The horrid sickening stench of the miasma must be experienced to be conceived." In water taken from this spot Mr. Daniel found sulphuretted hydrogen. In some of the specimens there were 6.7 to 11 cubic inches of it in a gallon.

18. From the same narrative, it appears, that sickness attacked the vessel twenty-seven days before their entrance into the river Nun. In removing a part of the cargo, it was discovered that the cause of a "disagreeable vapour, from which they had long suffered, was, that the bags containing the cocoa had rolled, and the cocoa had fallen into the salt bilge water and there become putrid."

19. The following account is extracted from Dr. Barrington's paper. The Hornet had been "salted," and was consequently very damp. When she was "broken out" at New York, after her return in 1828, great quantities of mud, and other filth were taken from her hold; and in her timbers and lower works was discovered a considerable collection of chips and shavings in a putrid state. The bilge water, and smell from the hold in this vessel were exceedingly unpleasant. On board this ship, yellow fever made its appearance whilst off Sacrificios, Mexico. The Peacock, which suffered also, was in much the same condition. The temperature averaged 84° F. This writer states, that "by experiments made on shipboard, 17 grains of chloride of lime decomposed all the sulphuretted hydrogen in half a pint of bilge water." (*Am. Journ. Med. Sci.* Aug. 1833, p. 307, *et seq.*)

20. New Orleans "is built on a soft alluvial soil, but a few feet above the water in the wells, the dampness is consequently very great; the streets are filthy." The attack of "Epidemic Yellow Fever of the autumn of 1833" is described by Dr. E. H. Barton. August—rain 8.17 inches; average thermometer 79.97 rising to 90° F., at midnight often 81°—84°. "From

the streets arose a very offensive odour." The streets were filthy and exhaled a peculiar offensive odour after rains. This writer quotes the tables of Philadelphia, and the authority of Sir G. Blane and M. Arejula, to prove that the fever does not occur at a lower temperature than 79°—82° F. (*Am. Journ. Med. Sci.* Nov. 1834.)

21. On the north side of Mobile, " the land is wet and swampy, consisting of a soft black mud, apparently without any solid foundation." " Persons residing there throughout the year, will be liable to the different grades of bilious or endemic fever of either the intermitting, remitting, or continued type." The well water is warm and *brackish.* The coast bordering the bay is considered unhealthy—" the sea-breeze blows over a quantity of decaying drift wood, and other perishable matters." Spring Hill being entirely free from stagnant water is healthy." Dr. Heustis, from whom the above facts are taken, remarks " that a range of temperature from 70° to 80° F. is necessary for the production of bilious endemic, or yellow fever—it should not fall below 70° at night, or 86° in the day." (*Am. J. Med. Sc.* Nov. 1836.)

22. Dr. Lucas gives an admirable account of the topography, and diseases of Montgomery county, Alabama, in the *American Journal of the Medical Sciences,* Nov. 1827, in which the same causes are pointed out as the producers of malaria, that are requisite for the evolution of sulphuretted hydrogen. Alluvial soil, vegetable decay, and high temperature are found in the most healthy parts.

Dr. Heustis introduces similar local causes to account for the autumnal remittent of Dallas county in the same state. (*Am. Journ. Med. Sci.* Feb. 1832.)

23. Charleston, South Carolina, has been visited by repeated attacks of yellow fever. One of 1827 is fully described by Prof. Dickson in the *American Journal of the Medical Sciences,* May, 1828. The city stands on a neck of land between two marshy rivers, the commercial part is built on alluvial soil; some of which is "made," having been formerly covered by creeks which intersected it in every direction. The materials used for filling up low swampy lots, are principally pine logs, oyster-shells, and rubbish of all kinds, and even scavengers' offals. The wharves are of wood filled up with those materials, and with mud drawn from the river. " You will readily infer that grounds thus *made* will be eminently fitted for generating, and giving off deleterious effluvia." The thermometer ranged from 82° to 90° in August, in the sun it reached 120°—125°—130° F., and at 2 o'clock A. M. with every door and window open, 86° F. This writer, as well as Dr. Lucas, remarks that negroes escape often in the most unhealthy seasons.

Dr. Simmons, in a report on Yellow Fever, read in 1839, remarks: " Stranger's fever requires a high temperature, ranging 85° F.—it is accompanied with moisture. In the docks (of Charleston) a good deal of mud, with decomposed vegetable, and other materials are thrown up by the tide, and at low water, the exhalations are offensive. At present the city is surrounded by marshes through which the salt water ebbs and flows." (*Am. Journ. Med. Sci.* Feb. 1840, p. 409.)

24. Augusta, Georgia, was visited by a severe endemic in 1839. A report, drawn up by a committee of physicians, attributes it to the exhalations given off from about 117,000 to 200,000 cubic feet of decaying animal and vegetable matter collected at the trash way, and reposing on the bed of the river, above the surface of which it rose. (*Am. Journ. Med. Sci.* Feb. 1840, p. 410.)

25. Dr. Hildreth, treating of the climate of Washington county, Ohio, remarks: "In 1807 the alluvial low grounds near the river, were inundated. In 1822, the water of the rivers and creeks was low, stagnant and putrid—the Ohio for two or three months resembled a long slimy lake." In 1823 the low grounds were deluged. (*Am. Journ. Med. Sci.* Feb. 1830.)

26. Batavia, the storehouse of pestilence, is thus described by Dr. Bettner. The islands in front of the harbour (used as cemeteries) obstruct the free passage of the sea-breeze, and contribute to the stillness of the water in the roads, which sometimes appears thick and partly stagnant; "imparting an unpleasant and unwholesome odour." "This atmosphere receives still further contributions from the canals of the city, and the surrounding marshes and jungles." The coast is alluvial—nights sultry and moist, range of the thermometer 90° F. (*Am. Journ. Med. Sci.* Aug. 1830, p. 380.)

27. St. Lucia is a small volcanic island, containing rich alluvial valleys, with morasses. The tropical vegetation accumulates large stores of decaying matter in the putrid swamps. Dr. Evans calls the exhalations from the marsh of Castries, deleterious; he smelt a disagreeable odour in crossing it, and was soon after taken with nausea, &c.

28. Smyrna is built on an alluvial plain, always moist. A sulphur spring exists near the town. Its commonest diseases are miasmatic fevers.

29. Mr. Darwin remarks that in certain parts of Peru, the sulphates of magnesia and soda effloresce upon the soil, and the mud of the neighbouring saline lakes is black and fetid. That the worst attacks of ague occur here, whereas *in Brazil many marshes with rank vegetation, exposed to ardent heat, are more healthy.*

30. Certain marshes, at the foot of the Ligurian Appenines, were until 1741 expused to an occasional influx of the sea, which, coming in contact with their decaying vegetable matter, produced the most deadly miasm. In that year the sea was shut out, and although the fresh water of the marshes stagnates, they have not since thrown up any malaria.

The same is true of the basins of Motrone, and Perotto. (See a paper by Signor G. Giorgini, *Annales de Chemie*, vol. 29.)

31. The intrusion of salt water into the marshes of Caitia, near Venezuela, produces the most fatal consequences. "So that negroes escape there, to avoid the attacks of the whites, as none dare to follow." Chagres owes its insalubrity to the surrounding swamps.

All the coasts on which mangroves flourish, are dangerous. The recess of the tide exposes to the air extensive surfaces of decaying vegetable matter,

acting on the sulphates of the sea water, and throwing into the air volumes of sulphuretted hydrogen. The deadly malaria of the South Carolina rice fields is produced by letting in the sea water to the young plants, by which the weeds infesting the rich alluvial grounds are destroyed, and abundance of sulphuretted hydrogen produced.

32. The places enumerated, with numerous others, in which bilious endemics occur, are characterized by the requisites for the generation of sulphuretted hydrogen gas. The worst fevers prevail on alluvial sea-coasts, and yellow fever seldom attacks any other places. The cases 17, 18, 19, 29, 30, 31 are sufficient to establish the present proposition, but the argument may be further fortified by the examination of certain places which have ceased to be unhealthy.

33. There is none perhaps more remarkable than the city of Calcutta, which, at first founded on a salt marsh, was deadly to Europeans. But the talents and industry of its colonists have rendered the place healthy by draining, cleaning, and paving it thoroughly. The fate of Fultah, below Calcutta, is different; from being the abode of luxury, it has relapsed into its primeval condition of a marshy jungle, where fever and pestilence prevail.

34. New York, before its marshes were filled up with the red sandstone detritus of the island, was liable to severe remittents. European writers on malaria speak to the present day of the yellow fever of that city.

Norfolk, Va., has rapidly improved in health, since the better paving of the streets.

35. Panama, once subject to the severest fevers, has become healthy by the destruction of the neighbouring forests.

36. We find also, that in those localities where one, or all the conditions necessary for the production of sulphuretted hydrogen are absent, malaria does not exist. Such is the case in Malta; the plains of Russia; the Sandwich islands; Gibraltar; the elevated plains of the Andes, and Mexico; table lands—of this kind is the western part of the state of Pennsylvania, reputed by Dr. Callaghan (*Am. Journ. Med. Sci.* Nov. 1828) to be free from all malaria; sandy deserts as those of Africa and Arabia; the pine barrens of Carolina, Georgia, Alabama, &c.

37. It would, however, be premature to state, that in every case where bilious fever has been detected, sulphuretted hydrogen also existed. The whole subject of malarious diseases is obscure. The catalogue of endemics attributed to this cause includes a host of ailments from ague to yellow fever, typhus and plague itself. There is some mistake here; either the exciting causes vary, or the whole of these diseases are not produced by miasma. Some of these complaints are undoubtedly produced by other causes. The discoveries in physiology made by Dr. Marshall Hall, have led to an axiom in medicine, at one time hardly suspected—*that dissimilar causes may produce similar symptoms;* which doctrine may be applied to the list of miasmatic diseases with profit.

The dispute between the contagiousness and non-contagiousness, the malarious or non-malarious origin of yellow fever, shows how undecided the profession are on this subject. This disease was called an epidemic in Gibraltar, in 1828—because of its appearance in a place which presents few of the characters of malarious localities.

38. In some of the cases adduced in the enumeration of places remarkable for malaria, it is questionable whether the means of generating sulphuretted hydrogen exist. This is the case in all inland positions, where it is uncertain that sulphates are found in the waters of the place. To decide so extensive a question, much diligent research undertaken by many persons is necessary. That the gas does exist inland has been proved by several sections, but whether the sites are malarious or not, remains to her determined. One case of the inland contemporaneous existence of miasm and the deleterious gas, I have had the means of observing. At a distance of ten miles from the college, an attack of bilious fever occurred about the middle of July, in the present year, prostrating about thirty servants. It was attributed to the frequent inundation of the low grounds of the plantation, during the spring. The individuals first attacked had been exposed to the fogs of the low grounds. Being interested in the matter, I paid the place a visit; and learned from the proprietor, that it had enjoyed an immunity for several years; and that a number of ditches had been recently dug in the marshy part of the lands. It occurred to me that this fresh exposure of alluvial soil might have been the cause of the invasion of disease, and I obtained permission to test the opinion by depositing two prepared coins (4) in the ditches. In a fortnight, which was the earliest opportunity of communication with the plantation, the coins were discoloured, notwithstanding the occurrence of freshets which interfered with the action of the reagent.

A number of cases similar to the preceding, would furnish the profession with the means of successful induction, and lead to the determination of the question under consideration. The means of submitting the proposition to experiment are so simple, as to induce a belief that before long the solution will be effected.

Proposition III.—*Certain agents have been supposed to give activity to the exhalations arising from marshes called malaria.*

39. There is no uniformity of opinion as to the deleterious agent. The vehicle which conveys it is, however, acknowledged by the inhabitants of the fens of Lincolnshire, the Italian, the American, and the Cingalesee, to be *dew.* All these observers and numerous theorists, coincide in this particular. There is an instinct in man, which warns him in a similar way. In consequence of this universal belief, that dew is an active agent in the production of this series of diseases, many have regarded watery vapour itself as the noxious matter.

40. Of those who have urged this proposition, Mr. T. Hopkins has

exhibited the most address. In his paper (No. 86 of the London and Edinburgh Philosophical Journal,) he has done much, by pointing out the philosophy of the action of watery vapour on the human frame, towards establishing his position.

It has been, moreover, his fortune to follow a list of opponents, who argued more from obstinacy than on just principles; and who were content with a *word* signifying nothing. Thus we have it asserted, that if watery vapour be the cause of malaria, it should exist in the winter!—and the question is asked, whether water is a poison? It was not such *physicians* that could stand against his perfect argument—*that as the atmospheric capacity for vapour decreased in high temperatures, the insensible perspiration of the human body must diminish, and at* 98° F. *dew point, it must cease altogether.*

The argument is indisputable as a physical law. The fact is unquestionable, that such a state of the dew point may exist. But bilious fever is not produced thereby. In the frightful mortality, that attended the first efforts to circumnavigate the globe, scurvy was the cause, and not yellow fever. It is not on the sea, but the sea-coast, marshy and rank with mangroves, that it prevails. On shores which are sandy and barren, let them be ever so saturated with water, there is no malaria. The centre of a broad stream, as the Chesapeake; or of a lake, as Ontario and Erie, is healthy, whilst the shores are pestiferous. In Choco, where rain falls constantly, malaria does not exist. Mountainous countries are seldom free from vapours, but are without bilious fevers. On the contrary, unusually wet weather, attended with inundations over the face of swampy lands, keeps off marsh fever. It is well known that the miasm arises from wet ground in the act of drying, as when the alluvial beds of rivers are exposed. The fevers of Egypt occur when the Nile has subsided, and the lands are in a muddy condition.

But if the theory under notice be correct, why do the diseases occur in autumn, which is in the United States frequently a dry season? Mr. Hopkins has furnished a table in his paper, which tells well against his doctrine.

"*Mean monthly hygrometrical return for the year* 1832, *in the Island of St. Vincent, as given in the official report.*

January,	68.°68	April,	67.°93	July,	70.°25	October,	69.°39
February,	67.°14	May,	69.°30	August,	69.°66	November,	69.°41
March,	67.°99	June,	69.°25	September,	69.°69	December,	67.°31

"The most sickly period," says he, "extends from August to December." But by the table the highest dew point is in July, and the numbers given for January, March, April, May and June, are so near those for October, November and December, that the difference of dew point would, by no one, be urged as the cause of yellow fever.

Let it be remembered that the attacks of fever which occur in the West Indies, with a dew point at 80° F. and upwards, take place at a certain period of the year; and yet during the preceding healthy months the dew

point has been at 60° F. and even 70° F., without any intermittent ague or remittent. Now, in the fens of England, in Holland, at Walcheren, the dew point seldom rises above 60° F., and yet those places are infested with malaria. The reduction to which the doctrine may thus be brought, is, that in the West Indies the mildest part of the year produces agues and intermittents; the spring—bilious fevers; and the summer and autumn—yellow fever. For, in the winter, the dew point reaches the malarious point of Lincolnshire and Cheshire—in the spring, that of Italy: and in the summer, that of the African coast. Which is not found to be true of any place whatsoever.

The theory is therefore untenable, but it cannot be denied that dew does exert a powerful influence in the production of malaria, although it is not the active principle.

41. Another theory, that earburetted hydrogen gas is the aetive agent, has been recently advocated by M. Boussingault. He detected carbon in the dew eollected over the marshes of Ain, and the lagoons of Cartago in the valley of the river Cauca. After sunset he exposed watch glasses to the air of the marshes, and collected the falling dew, which he tested by pure sulphuric acid; it yielded a trace of carbonaceous matter. He found hydrogen in the same situation, and eame to the conclusion that the carbon existed as earburetted hydrogen. This discovery by direct examination is worthy of all praise, and removes the reproach, from the analytic art, of being unable to detect minute adulterations in the air. But it is no more than a piece of admirable manipulation. No one who has visited a marsh has failed to witness the evolution of earburretted hydrogen: it is constantly taking place.

This gas is one of the products of the putrefaetive fermentation of vegetable matters. It will, therefore, be met wherever that process is taking place. But the conditions which increase the unhealthiness of particular localities do not eontribute to the increase of the gas. The most dangerous sites are on the sea-coast, and where sea water finds access to marshes. These circumstances, which augment, and even produce malaria, (29, 30, 30,) are in no way concerned in the development of earburetted hydrogen gas.

42. Numerous other doctrines have been advanced in this matter. Hypothetical germs of every shape and character imaginable, of inconsistent properties, or possessing the power of ingenious accommodation to the wants of the case, have been proposed by learned doctors. Some have endowed them with phases of good and evil. Others pass them through cycles of transformation, like the locust appearing suddenly and destroying with voracity, and disappearing without warning, and burying themselves for years in the inactive form of the chrysalis. To Lancisci we are indebted for the destruction of the theory, which attributed malaria to the action of insects. Carbonic acid is too diffusible to rest on the surface of marshes: this is true of all uncombined gases. Moscati found no difference in the proportion of carbonic acid existing in a malarious and healthy site.

Proposition IV.—*The properties of malaria are fully recognised by the profession.*

43. It prevails usually in the autumnal months, corresponding to the fall of the leaf. Frost, and low temperatures destroy malaria. The summer is commonly free from it.

44. Night and morning dews appear to be the vehicle of the poison. It has always been recognised as existing with humidity in the air. The sultriness, complained of in malarious districts, is due to the action of moisture arresting the insensible perspiration of the body, and thereby destroying the natural means of reducing its temperature.

45. Malaria arises from muddy low lands, rather than extensive surfaces of water. The heat of the sun is reflected in a great degree from water, but the exposed beds of rivers and ponds absorb nearly every ray that falls upon them. Water does not transmit heat downwards, therefore the action of temperature upon the earth it covers is arrested to a great extent; and the process of vegetable decomposition, so far as heat is concerned, is impeded rather than advanced. It is therefore the sides, and shores of rivers, and the sea, that throw off malaria.

46. Elevated positions are free from the noxious body. Hence, a retreat into the upper rooms of a house has been known to secure the inmates. It exists only close to the source, and does not diffuse itself to any distance, except horizontally, or up the side of a hill with a gradual ascent. The wind when cooler than the air, by condensing the vapour over marshes, may carry it to a limited distance.

47. The rays of the sun, or in other words the higher capacity for moisture created by them, disperses malaria, by causing the moisture with which it is combined, to be diffused into the air. The direct action of light may, however, influence the destruction of this agent.

48. A grove, or other collection of trees, existing between the source of the poison and human habitations, is said to be a secure protection. They act by absorbing the watery vapour, and thereby decomposing the malaria.

49. A high wall, by hindering the poison from passing over it, is also a valuable protection.

50. Fire destroys malaria.

51. The first symptoms of malarious fevers are, dryness of the skin, diminution of urine, bilious and other congestions, and nervous prostration.

52. Cleanliness irrigation, the cultivation of swampy lands, the annual destruction by fire of marsh vegetation, and free ditching are known to diminish the sources of malaria. The cutting off of the sea, from marshes, is an invaluable preservative.

53. Chlorine, and dryness of the atmosphere destroy malaria.

Proposition V.—*Sulphuretted hydrogen is the active agent, in the pro-*

duction of those forms of malarious fevers met on the sea-coast, and the diseases belonging to the same class found inland.

54. Sulphuretted hydrogen has been discovered on the most deadly coasts. It is produced in marshes where sulphates exist either in the vegetable matter, water, or soil. The destruction of the sources of the gas, by the exclusion of the sea, has annihilated the fatal malaria of some of the Italian marshes and given health to the pestiferous town of Viareggio. The inhabitants near the basins of Motrone, Perotto, Montignosso, and Tonfalo have by the same precautions rescued themselves from these diseases. The same is true of Central America. In many of the above cases, the marshes still exist, and the fresh water lying over them is occasionally let off by sluices, and folding doors, so that carburetted hydrogen is generated, but not sulphuretted hydrogen gas.

55. The form in which sulphur exists in malaria is a matter of less consequence. It most probably forms one of the components of an organic body, containing carbon, hydrogen, sulphur and water. The reasons which induce me to believe in its organic form are various. They are as follows:

(*a*) The property of diffusion common to gases, belongs also to sulphuretted hydrogen. It is therefore impossible, that the gas thrown out by a marsh can rest upon its surface, but must be carried at once into the surrounding atmosphere. The presence of water in the air would not destroy the diffusibility of the gas, as has been supposed in the case of carburetted hydrogen, by Dr. Faust, (No. 11, *Am. Journ. Med. Sciences,*) unless a chemical union took place between them. For water, containing a gas in solution, must transmit it by exosmose into the air, until the latter contains as much as the former. Nor would the existence of a fog destroy the diffusiveness of the gas evolved from a marsh.

(*b*) The quantity of gas in the air, would seldom be sufficiently large to produce dangerous effects, if it were allowed to diffuse itself as fast as it was generated.

(c) The greatest bulk of gas is given off during the heat of the day, and that period should be the most dangerous, whereas it is known not to be so. But an organic compound containing water would of necessity cease to exist if the water lost its form and was diffused by the agency of heat. (*See section* 47.)

(*d*) Moscati, M. Rigaud de l'Isle, and Boussingault, discovered minute flocks, in the dew collected over malarious places. The last of these experimenters concluded that the flocks were the poisonous particles, and that they were organic. Rigaud de l'Isle found that nitrate of silver afforded with the dew of the marshes of Languedoc, a precipitate which became purple. Moscati proposed the use of a veil, as a preventive against infection from malaria, by the exclusion of the flocks. These organic particles are subject to decomposition, and then yield an offensive odour. The readiness, with which they run into a state of decay, is exceedingly great.

(*e*) There is but one point which appears to be opposed to the doctrine of the organic nature of malaria. It is, the rapidity with which it yields its sulphuretted hydrogen to silver, so as to be almost spontaneously decomposable. The compound should, however, possess but little chemical cohesion, for it is evident, that, in its action on the human frame, the sulphuretted hydrogen is the active agent, and probably separates itself from the other components, as soon as it reaches the circulation.

56. The agents which decompose sulphuretted hydrogen are also inimical to malaria. Fire is of this number, for by means of it the gas is converted, in the open air, into sulphurous acid and water. Chlorine destroys both malaria and sulphuretted hydrogen, the latter by combining with its hydrogen and precipitating the inert element sulphur. The value of chlorine has been proved both in the American and British squadrons.

57. The existence of trees, by decomposing the organic compound, and appropriating its water, is calculated to destroy malaria.

58. Its weight, and the readiness with which water may be separated from it, preclude its rising to any altitude in the atmosphere.

59. It is produced in the autumnal months; because then, the amount of moisture, the coolness of the nights over the temperature of the days, and the fresh deposition of leaves, furnish the most abundant materials for the formation of the organic compound.

60. The poisonous effects of sulphuretted hydrogen are too well known to require comment. There is no agent, which marshes evolve, that is so destructive to life. Messrs. Thenard and Dupuytren killed birds in an atmosphere containing $\frac{1}{1500}$ part of the gas. Nysten found that it was absorbed at once by the blood. Two or three cubic inches caused immediate death when injected into a vein, the cavity of the chest, or the cellular tissue of a dog. The same authority, with Lebküchoer, and Chaussier found that it was absorbed through the healthy skin, and produced dangerous effects. The gas is a narcotic poison, prostrating the nervous system, and destroying muscular energy. In small quantities it produces colic, and internal congestions.

61. Sulphuretted hydrogen is thrown off from the healthy skin, along with the insensible perspiration. This may be tested by wearing a prepared coin. Negroes throw off a larger quantity, than white persons.

To arrest this discharge, or introduce into the system a quantity of the same deleterious gas, must lead to disease. When miasm is inhaled, the latter condition is produced.

Watery vapour saturating a high temperature, by putting a stop to insensible perspiration does not arrest the discharge of sulphuretted hydrogen necessarily. Moreover, the kidneys are known to act vicariously for the skin, as far as the discharge of water is concerned.

But the presence of sulphuretted hydrogen in the system, cannot be obviated by any vicarious action; for it does not form an ingredient of the blood;

but is an excrement thrown out by the skin, after having been elaborated by it on the spot, and without ever entering the circulation. It must therefore produce a series of morbid results, before it escapes from the body, which are, in our theory, the symptoms of the diseases known as bilious, yellow, and jungle fever, or their milder forms.

Liebig states, that sulphuretted hydrogen produces immediate decomposition of the blood.

62. It may be a confirmation of the present theory with some persons, to know, that the inhabitants of Italy have long attributed malaria to sulphurous exhalations.

63. Persons who have been long resident in swampy regions, acquire the habit of resisting the action of malaria. But they are without confirmed health. Negroes are less subject to disease from malaria, than white persons, and especially strangers. From the amount of sulphuretted hydrogen that negroes exhale, it appears to me, that the exemption the natives of marshes finally acquire may be due to the establishment of an increased action by the skin, so that the poison is thrown out almost as rapidly as it is inhaled. Toxicologists give us instances of the consumption of ounces of opium and other narcotics, without fatal effects, by persons who have habituated themselves gradually to the use of the poison.

64. The two most efficient remedies in cases of bilious fever, contain chlorine. The nitro-muriatic acid bath owes all its activity to the absorption of chlorine by the skin. Calomel is a chloride of mercury, and is absorbed with the circulation, for it has been discovered in the blood by Schubarth and others.

Sulphuretted hydrogen is absorbed into the circulation, according to the evidence of Nysten, Chaussier, &c.

The existence of these two bodies in the blood cannot take place without a decomposition of sulphuretted hydrogen, the chlorine appropriating the hydrogen, and throwing down inert sulphur. This reaction is not conjectural, for in a case of poisoning related by Wibmer, where chlorine had been inhaled by a young man with the most serious results, the breathing of a little sulphuretted hydrogen produced a rapid recovery. Nor was the recovery due to any action on the nervous system, for ammonia, which had been given before the sulphuretted hydrogen, did no good whatever.

The use of these remedies in malarious diseases is, therefore, a powerful argument in favour of the present doctrine.

The means discovered for the detection of sulphuretted hydrogen, places this important question in the hands of the profession—little skill or time is required to test the existence of the gas, during an endemic. By recording observations, made with so much ease, in the medical journals, the accuracy of the present doctrine will be proved or disproved. All that is demanded, on the part of the writer, is an unprejudiced examination, by

experiment, of the question. It is not expected that other theories will be hastily discarded, but the judgment of the profession is confidently appealed to in the final decision of the point. With one practical remark I shall conclude this paper:—Sulphuretted hydrogen is not given off constantly by the same marsh; its quantity is seldom sufficiently great to blacken silver; the discoloration reaches a brownish golden colour, and seldom advances beyond it; this may be due to the presence of other substances besides sulphur, in the compound which acts upon silver.

[We append, at the request of the author, the following letter which he has addressed us.—*Editor.*]

Doct. Hays.

Dear Sir:—Unfortunately I was from home when your favour arrived, or it would have been answered at an earlier period. The instance of Boston,* which you adduce in opposition to my views, is new to me, but your remarks have directed my attention to a cause of discrepancy which may sometimes occur. The extensive bog lands of Ireland are free from malaria, whereas the fens of Lincolnshire, situated in a similar climate, are surcharged with it. In the former case, the absence of poisonous exhalations is probably due to the presence of *iron* in the subsoil.

The iron may be in any form whatever, but if its electro-negative ingredient contain oxygen, it will be decomposed by the same force which overcomes the affinity of that substance in the sulphuric acid of the saline matters. This force has been spoken of hitherto, as due to the affinity of *carbon* for oxygen, but from the recent researches of Dr. Liebig it appears to be much more probable that the *hydrogen* of organic matter is the active body. The salt of iron suffering decomposition, there will be produced some new compound differing with the acid. If carbonate of iron be present and its oxygen be appropriated by the hydrogen of decaying matter, a carburet or plumbago will be formed. If a sulphate of iron be deoxidized the sulphuret results.

But the case which is immediately before us is:—where a sulphate of lime, magnesia, &c. is decomposed, and iron is likewise liberated from one of its compounds. Sulphuretted hydrogen is not in this instance formed *at all*, because the *free iron* exerts a more powerful affinity for sulphur than hydrogen does, and the insoluble sulphuret of the metal results instead of a gas. A marsh in which this action takes place will therefore be free from malaria, like the Irish bogs, unless other agents exist in the production of the poison than those contemplated in my paper.

Iron is not the only substance that may bring about this result, for zinc and many other metals unite with sulphur with great readiness. It is, however, the most frequent and important substance which exists in bogs or marshes. The amount will influence the result, for there may be too small

* [Boston has very extensive marshes in its immediate vicinity, yet intermittent fever is unknown there.—*Ed.*]

a quantity of iron present in some instances to combine with all the nascent sulphur. It is supposed by Liebig that the pyrites and zinc blende of coal owe their origin to the changes we have been considering.

I am glad that your letter has induced me to consider the negative of my proposition, that sulphuretted hydrogen exists in stagnant waters, because, the foregoing remarks may assist in pointing out the cause of the healthiness of some marshy lands, and also turn the attention of physicians to a means of remedying the production of sulphuretted hydrogen, in the streets of cities, &c., by freely distributing powdered iron ore as a preventive. Should it answer, the smallness of the expense, and the absence of smell, would constitute it a desirable substitute for the chloride of lime. The hæmatite ores would probably succeed best, but experiment alone can decide this question; and should opportunity serve, I shall examine the subject at an early period.

Whether the neighbourhood of Boston owes its exemption to the presence of a metal in the soil, or not, is worthy of investigation. But the quantity of water, the ingress of tides, winds, and other causes may in this instance destroy the malaria if formed. Amongst the localities enumerated, in which the influence of sea water is apparent, I beg to add that of Sheerness, England, the salt marshes of which are exceedingly insalubrious.

Allow me to remain, with the highest respect, yours truly,

D. P. Gardner.

Prince Edward C. H., Dec. 5th, 1842.

Art. III.—*Excision of the Olecranon Process for Anchylosis of the Elbow-joint.* By Gurdon Buck, Jr., M.D., one of the Surgeons of the New York Hospital.

John M'Cormick, an ostler, of robust constitution, born in Ireland, aged 28 years, was admitted into the New York Hospital, September 27th, 1842, with anchylosis of the right elbow-joint, from an injury received more than a year before, in falling through a trap-door with great force upon the elbow. Owing to the swelling that succeeded, the nature of the injury was rendered obscure. Extensive inflammation soon followed, involving the limb above and below the joint, and going on to suppuration. At the expiration of thirteen weeks, when he was able to go about, the joint was stiff as at the time of his admission, when the limb was flexed in a position intermediate between a right angle and complete extension. No swelling or appearance of inflammation remained, and the general contour of the joint was natural, with the exception of the olecranon, which was expanded and uneven upon its surface with a bony prominence on either margin at an inch from its extremity. The head of the radius rotated with a creaking, cartilaginous